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PRELIMINARY NANOSIMS ANALYSIS OF CARBON ISOTOPE OF CARBONATES IN CALCIUM-ALUMINUM-RICH INCLUSIONS

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Introduction: Carbonate minerals observed in primitive meteorites are products of either terrestrial weathering or aqueous alteration in the early solar system. Most of the carbonate minerals in carbonaceous chondrites occur primarily as isolated grains in matrix, as crosscutting veins, or as replacement minerals in chondrules [e.g., 1, 2]. A few calcium-aluminum-rich inclusions (CAIs) have been reported containing carbonate minerals as well [2, 3]. The C and O isotopes of carbonates in carbonaceous chondrites, mostly measured by stepwise extraction of bulk samples with phosphoric acid [4–7], are largely distinctive from those of terrestrial carbonates, whereas textural and petrographic evidence indicates that some carbonates in primitive meteorites are terrestrial in origin [2]. This study attempts to investigate from the aspect of C isotope the origin of rare carbonate minerals in some CAIs. If of extraterrestrial origin, carbonates in CAIs can provide important information and constraints on the ubiquitous aqueous alteration process in the early solar system.

Samples and Analytical Techniques: We have selected carbonate-bearing CAIs from Murchison (CM) and Leoville (CV) for this study. One of the CAIs from Murchison is the extensively studied Blue Angel—an altered hibonite inclusion containing large amount calcite (10–70 μm) [3]. The other Murchison CAI is a 100 × 50 μm calcite fragment enclosing small grains of spinel, melilite, fassaite and perovskite. The calcite in the type B Leoville 3537-2 CAI occurs as narrow veins (less than ~10 μm) at the center of the inclusion. Carbon isotope was measured with the Caltech NanoSIMS 50L ion microprobe. A rastering (3x3 μm) primary beam of ~10 pA was used to sputter the sample and generate secondary ions. Both ^{12}C and ^{13}C were simultaneously collected with EMs. Carbonate standards (calcite, dolomite, magnesium, and siderite) were used to check possible matrix effect and instrumental mass fractionation (IMF). Typical analytical errors under such conditions are ~1–2‰ (1ó) for $\delta^{13}C$.

Results and Discussion: The results from standard measurements indicate that there are significant matrix effects in C isotope analysis of carbonates with a NanoSIMS. The IMF increases by ~30‰ from calcite to dolomite, magnesium, and siderite. To date, three calcite grains from the Blue Angel CAI were analyzed for their C isotope, yielding $\delta^{13}C$ values from +16 to + 23‰. Three spots on a calcite vein in Leoville 3537-2, on the other hand, show lower $\delta^{13}C$ values from—2 to—8‰. Though these CAI carbonate data fall within the ranges obtained from bulk measurements of CM or CV meteorites [4], the $\delta^{13}C$ values are not high enough to exclude a terrestrial origin for the Leoville sample. Oxygen isotope data are needed to further constrain the nature of the CAI carbonates. Nonetheless, the data suggest that there is no presolar C component in CM CAI carbonates that could be responsible for the peculiar high $\delta^{13}C$ values observed in some bulk carbonates.

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A PRESOLAR SPINEL GRAIN OF PROBABLE NOVA ORIGIN

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Introduction: Presolar grains from novae are exceedingly rare. A few SiC and graphite grains have been identified by large ^{13}C, ^{15}N, and ^{30}Si excesses [1, 2]. While some purported nova grains may have actually condensed in a supernova [3], some are undoubtedly nova condensates [4, 5]. Except in rare cases, the material ejected in nova explosions is O-rich, and it remains a puzzle why to date only carbonaceous phases, with one possible exception [6], have been identified. Here we report the discovery of a presolar spinel grain with a likely nova origin.

Experimental: The "CG" residue of Murray, prepared by physical and chemical separation [7] and consisting of high concentrations of spinel grains (diameter ~0.5 μm), was scanned for O-anomalous grains with an automated measurement technique recently developed for the NanoSIMS [8]. Grain C4–8 was not identified by the particle definition software, but was recognized as an ^{17}O hotspot in an ion image taken during the automated surveys. High-resolution SEM images confirmed that it was surrounded by multiple grains. Subsequent removal of surrounding isotopically normal material [9] and manual measurement of $^{16,17,18}O$ revealed the grain to be extremely enriched in ^{17}O. Following O isotopic analysis, $^{24,25,26}Mg^+$ and $^{27}Al^+$ were measured in multicollection mode with an O^- primary beam in a separate measurement session.

Results: The O isotopic composition of C4–8 is characterized by a huge enrichment in ^{17}O and a modest depletion in ^{18}O, with $^{17}O/^{16}O = (4.40 \pm 0.01) \times 10^{-2}$ and $^{18}O/^{16}O = (1.10 \pm 0.02) \times 10^{-3}$. This isotopic signature is similar to that of Group 1 grains [10]. However, RGB and AGB stars undergoing 1st and 2nd dredge-up, the most likely sources of these grains [11], cannot produce $^{17}O/^{16}O > 4 \times 10^{-3}$ [12]. C4–8 is significantly enriched in $^{25,26}Mg$ ($\delta^{25}Mg = 949 \pm 9‰$ and $\delta^{26}Mg = 929 \pm 7‰$) and, similar to the situation for O, nucleosynthesis in the O-rich envelope of AGB stars ($\lesssim 3M_\odot$) cannot produce $\delta^{25}Mg \gtrsim 40‰$ [13]. The most likely condensation environment for a grain with extreme enrichments in both ^{17}O and ^{25}Mg is found in nova ejecta. The best match for the O isotopes in C4–8 is achieved by models for CO novae with a 0.8 or $1.15M_\odot$ white dwarf; however, the Mg isotopic composition is much better explained by a 0.6 $M_\odot$ CO model [2]. The only other putative nova oxide identified so far, T54 [14], is also ^{17}O rich, but has not been analyzed for Mg/Al and cannot help refine the model predictions. Recent model calculations have indicated nova nucleosynthesis beyond Ca [5], and future isotopic measurements (e.g., Ca, Ti) of C4–8 are planned to better constrain the origin of this unique grain.

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